



NuSTORM accelerator: Challenges and opportunities



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NuSTORM accelerator challenges

- nuSTORM is a unique facility providing:
 - High muon rate
 - Well-characterised neutrino beam
- Several applications
 - Measurement of neutrino scattering cross sections
 - Search for sterile neutrinos and other BSM physics
 - Provide a technology test-bed for the muon collider
- What is the nuSTORM facility?
- How can it provide a test-bed for the muon collider?



nuSTORM facility

- What is the nuSTORM facility?

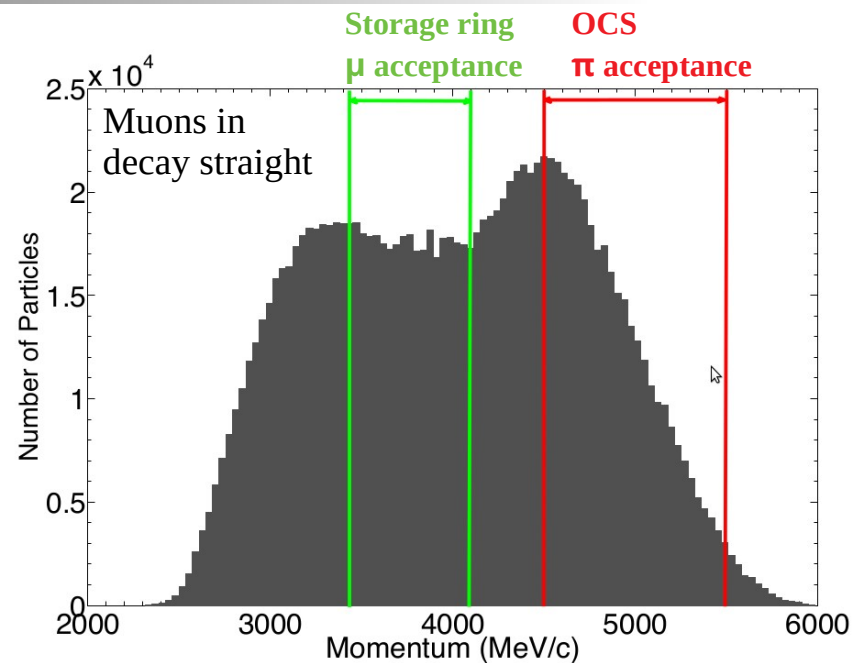
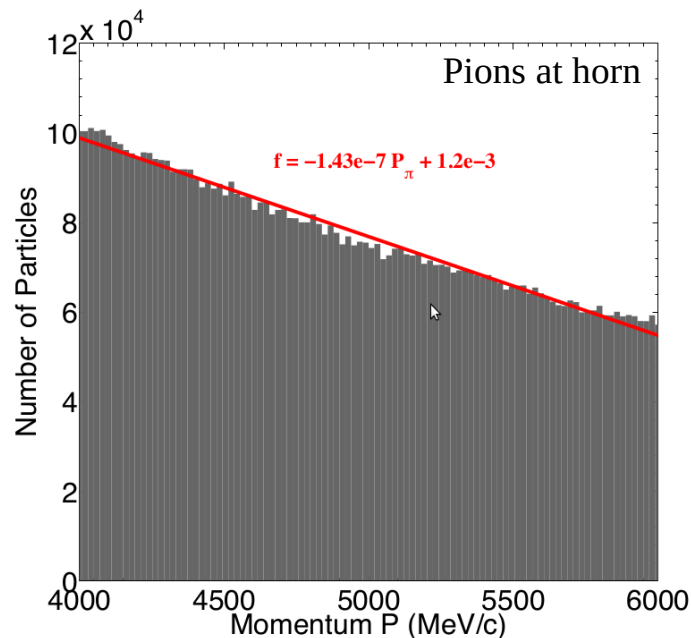


nuSTORM at CERN – Feasibility Study, Ahdida et al, CERN-PBC-REPORT-2019-003, 2020

- Main features
 - ~250 kW target station
 - Pion transport line
 - Stochastic muon capture into storage ring
 - Option for conventional FODO ring or high aperture FFA ring



Stochastic Muon Capture

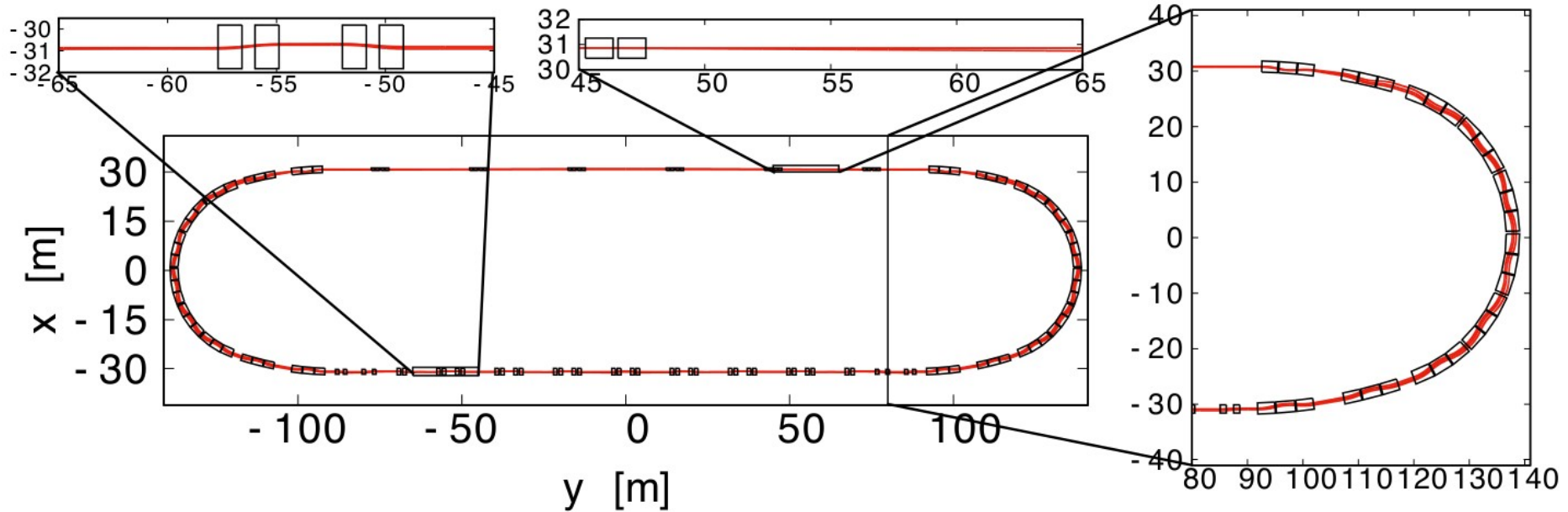


- Pions injected into the decay ring
- Capture muons that decay backwards in pion CoM frame
- Undecayed pions and forwards muons diverted into muon test area
 - Extraction line at end of first decay straight



Storage Ring

nuSTORM at CERN – Feasibility Study, Ahdida et al, CERN-PBC-REPORT-2019-003, 2020



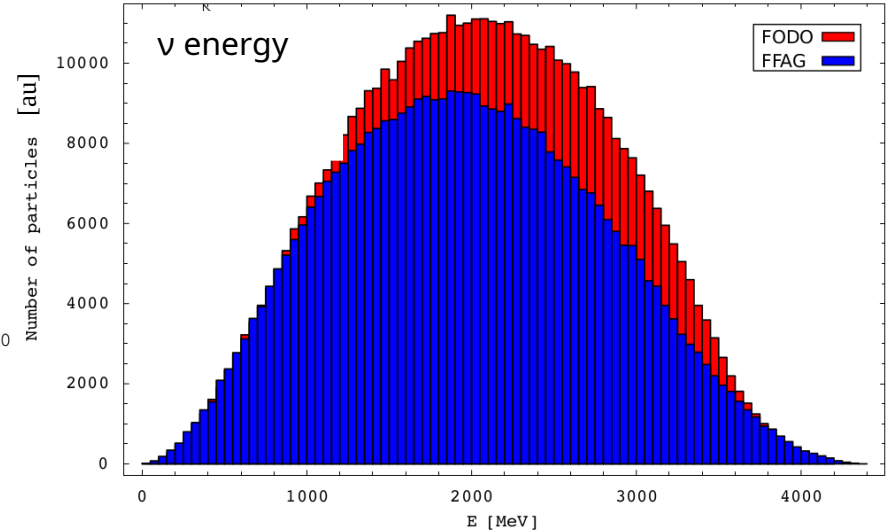
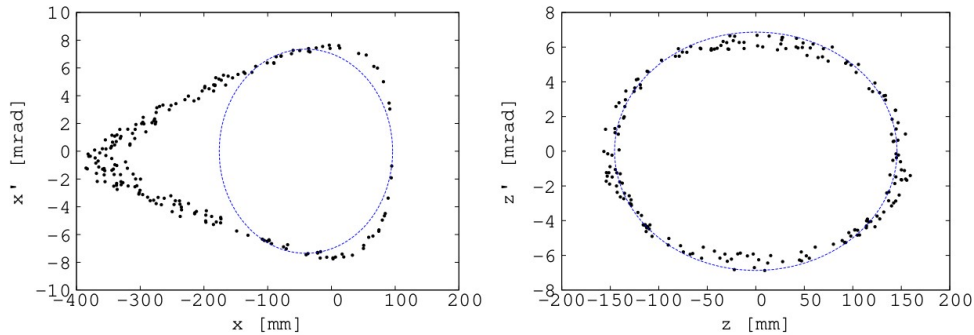
- Storage ring technologies:
 - Conventional FoDo ring
 - High acceptance FFA ring



Storage Ring

Lagrange et al, Racetrack FFAG muon decay ring for nuSTORM with triplet focusing, J. Inst 13 (2018)

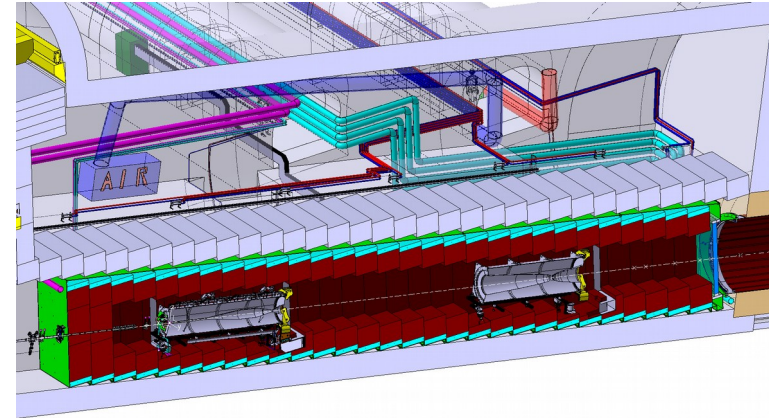
μ phase space



- Neutrinos momentum range up to 4 GeV
- Tunable ring energy under investigation
 - Optimisation so far has focused on 3.8 GeV μ
 - Higher energy would give more reach to cross section measurements
- Optimisation of storage ring to give improved neutrino flux
 - Hybrid FoDo straights with high acceptance FFA bends



NuSTORM Challenges



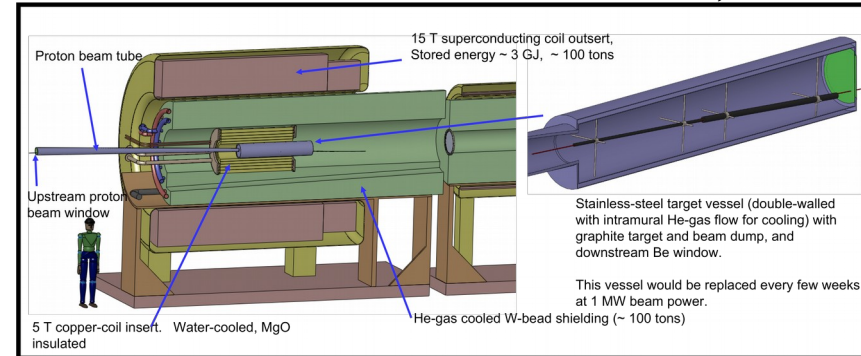
- Capture of high current pion beam
 - Normal conducting transport line near target
- Containment of tertiary beam (i.e. muons)
 - Large momentum spread and transverse size
 - Superconducting combined function dipoles in muon ring



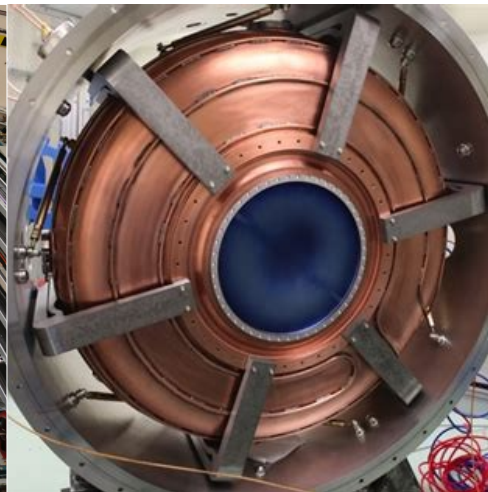
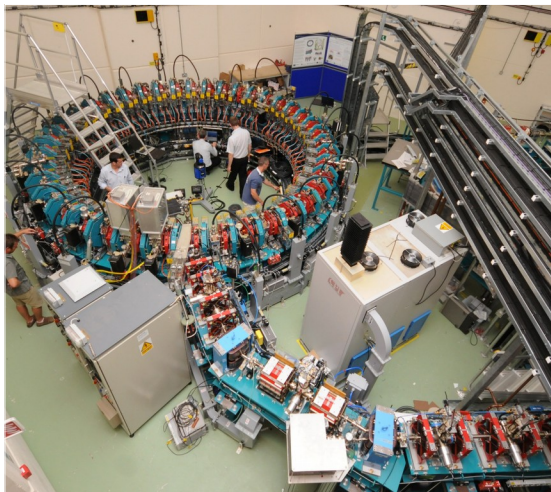
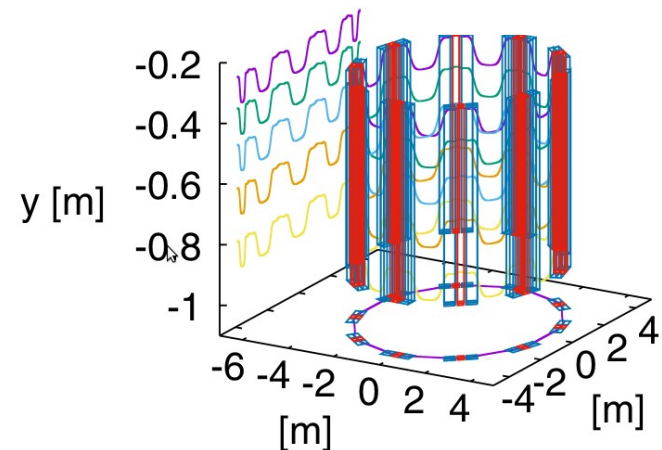
Muon Collider Challenges

- Capture of high current pion beam
- Containment of tertiary beam
- Cooling of tertiary beam
- Rapid acceleration and storage
 - Either conventional FODO-based Rapid Cycling Synchrotron
 - Or an FFA

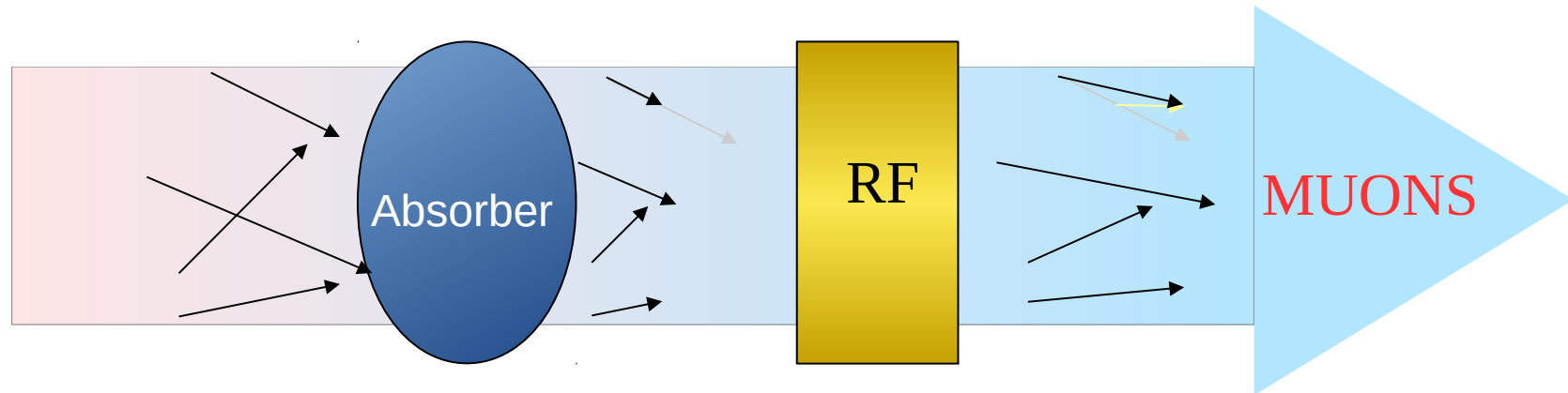
X. Ding et al, Carbon and Mercury target system for muon colliders and neutrino factories, IPAC16



Low energy vFFA PoP
Arxiv 2011.10783 (accepted in PRAB)



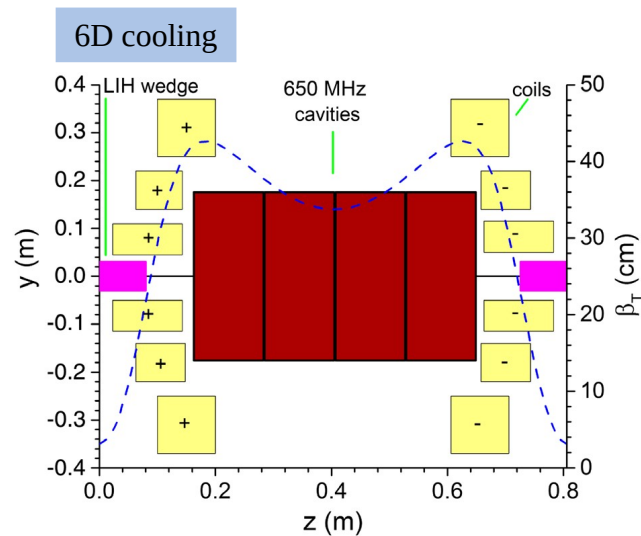
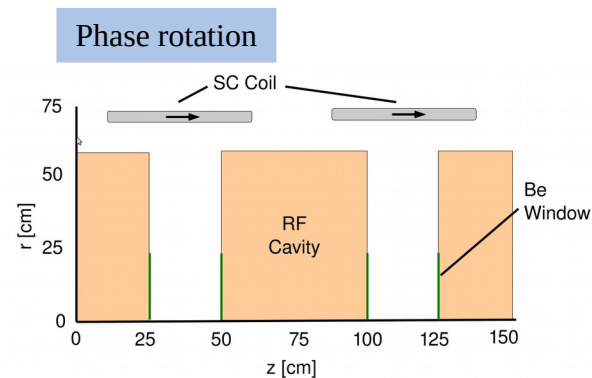
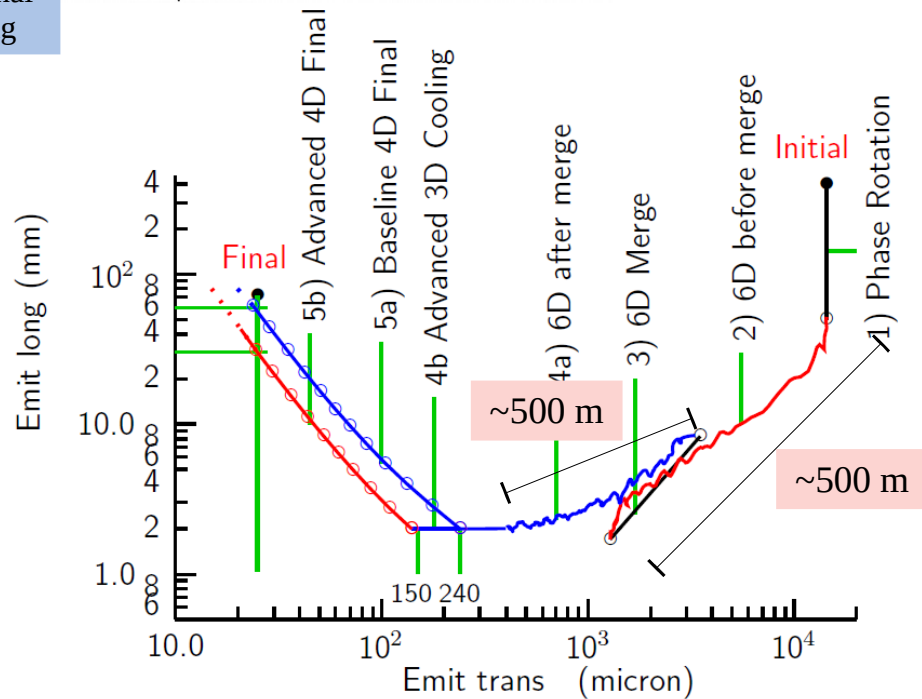
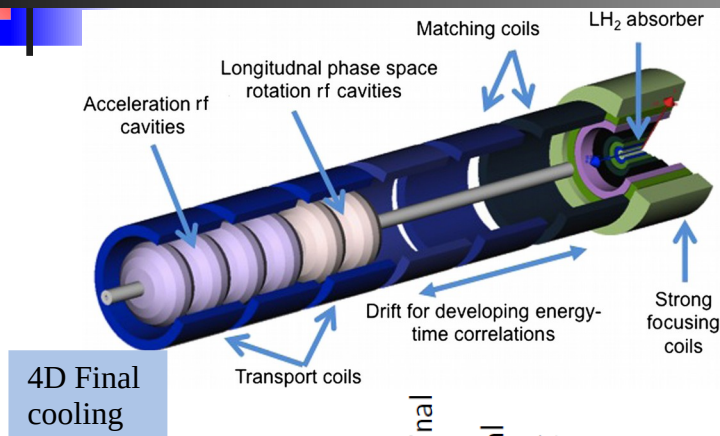
Ionisation Cooling



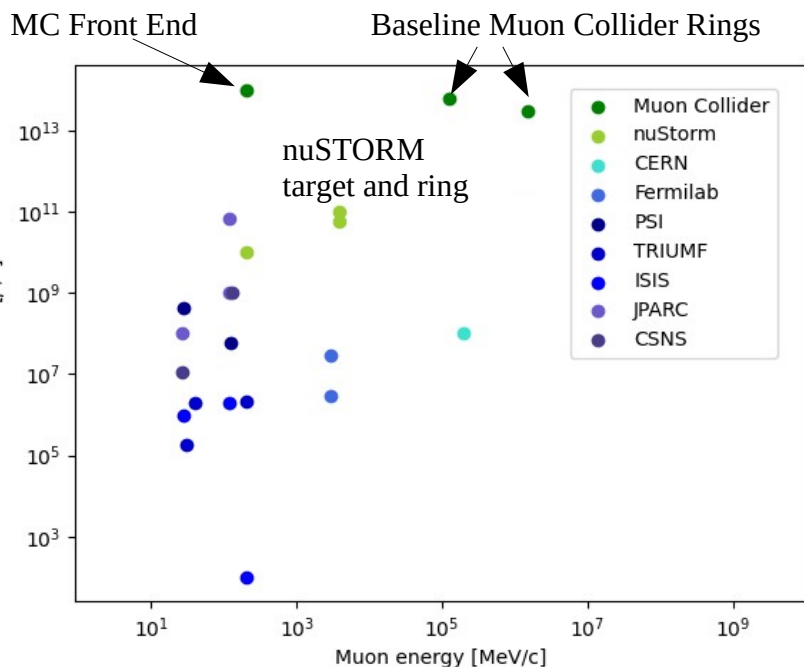
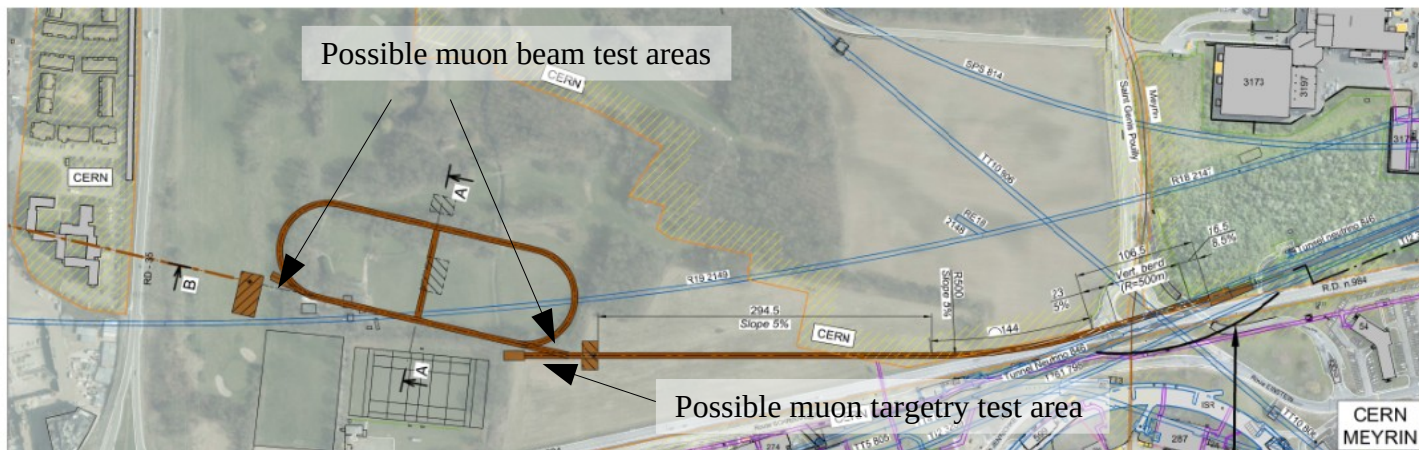
- Beam loses energy in absorbing material
 - Absorber removes momentum in all directions
 - RF cavity replaces momentum only in longitudinal direction
 - End up with beam that is more straight
- Multiple Coulomb scattering from nucleus ruins the effect
 - Mitigate with tight focussing
 - Mitigate with low-Z materials
 - Equilibrium emittance where MCS completely cancels the cooling



Muon Cooling



Survey of Muon Beamlines



- NuSTORM would make an excellent facility
 - One of the highest current high energy muon beams
- Target/irradiation test area
- Muon beam physics tests



Summary

- nuSTORM facility ideal facility for a number of aims
 - Measure neutrino scattering cross sections
 - Search for sterile neutrinos and other BSM physics
 - Provide a technology test-bed for the muon collider
- Unique facility to yield
 - High muon rate
 - Well-characterised beam
- Potential to be the highest current high energy muon beam

